

REMARKS

Claims 3-23, and 25-31 are in the application. Claims 6, 9, 11, 14, 16, 18, 20, 21, 27, and 29 are amended to overcome various rejections under 35 USC 112, as discussed in greater detail below. Claim 1 is replaced with new Claim 31 to emphasize distinctions over cited art by incorporating therein the limitations additional features in the process steps, as set forth on page 16, lines 3-4 and lines 30-32 and on page 18, lines 22-26 and by separating prior art process steps from the steps of the present invention. Claims 3, 8, 12, 13, 15, 19, 23, and 25 are amended to appropriately change the dependencies thereof. Claim 7 is amended to add argon as an inert gas; basis for this change is found on page 16, line 28.

The specification is amended on pages 1, 2, 7, 9, 10, 13, 19, 21, and 22 to clarify the distinction between "substrate" and "devices", in which a substrate is commonly understood by one skilled in this art to comprise a portion of a device. The terms are believed to be properly used on page 12, lines 25-31.

Claims 6, 9, 11, 14, 16, 18, 20, 21, 27, and 29 are rejected under 35 USC 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as the invention. The points raised by the Examiner are dealt with serially.

(A) The Examiner still considers Claims 6-7 to be indefinite because Claim 6 utilizes the same letters (a, b, and d) as Claim 1 to designate different processing steps.

Applicants have amended Claim 6 to specifically refer to "step x" of new Claim 31, which sub-steps noted under that step. For example, "step (a)" in Claim 6 refers to step (a) of Claim 31, and "(a1)" and "(a2)" designate sub-steps under step (a). Applicants believe that no confusion should remain with Claim 6 as presently amended. Since Claim 7 depends from Claim 6, that claim should now also be conform to 35 USC 112, second paragraph. If the Examiner continues to object to the language of Claim 6, he is invited to suggest appropriate changes.

(B) The Examiner contends that Claims 9, 16, 21, and 27 are indefinite because it is not clear how different gases (active and inert) can be selected from the same group of gases.

Applicants have amended Claims 9, 16, 21, and 27 to specify that the active gases are oxygen, nitrous oxide, steam, and vapor phase hydrogen peroxide and to specify that the inert gases are nitrogen and argon. The reactive gases are identified as such on page 18, lines 5-12, for example, while the inert gases are identified as such on page 16, lines 26-28.

(C) The Examiner contends that Claim 11 is indefinite for its recitation of “suitable wavelength” and inclusion of UV radiation.

It is clear from the specification that the term “electromagnetic radiation” includes at least ultraviolet (UV) radiation, infrared (IR) radiation, and laser energy; see, e.g., page 16, lines 4-10. Applicants have amended Claim 11 to be consistent with Claims 14, 18, 20, and 29, as amended herein.

(D) The Examiner contends that Claims 14, 18, 20, and 29 are indefinite in containing an improper Markush group (broad recitation of electromagnetic radiation and narrow limitation of UV radiation).

Claims 14, 18, 20, and 29 are amended to delete the narrow limitation of UV radiation.

Reconsideration of the rejection of Claims 6, 9, 11, 14, 16, 18, 20, 21, 27, and 29, as amended, under 35 USC 112, second paragraph, is respectfully requested.

The Examiner objects to Claims 3-5 under 37 CFR 1.75(c) as being of improper dependent form for failing to further limit the subject matter of a previous claim.

The confusion resulting in the objection comes from a less-than-clear definition of substrate, which makes it appear that “substrate” and “device” are synonymous. Of course, they are not; as one skilled in this art knows, a substrate is at least a portion of a device, but is not the device itself. Claim 31 is re-written to emphasize this distinction. Further, the specification is amended at appropriate locations to clear up any confusion.

Having clarified the distinction between substrate and device in new Claim 31, Applicants assert that Claims 3-5 properly limit the subject matter of Claim 31 by specifying more narrow embodiments of substrates treated by the method of Claim 31.

Reconsideration of the objection to Claims 3-5 under 37 CFR 1.75(c) is respectfully requested.

Claims 1, 3-23, and 25-30 are rejected under 35 USC 102(b) as being anticipated by Settineri et al (U.S. Patent 4,363,673). Claim 1 is replaced with new Claim 31.

The Settineri et al reference was discussed in Applicants' previous Amendment filed on February 18, 2000. The remarks therein obtain here as well.

New independent Claim 31 is based on canceled Claim 1, placing the sulfur trioxide process step and the rinse step in the preamble and leaving the precursor treatment step and the post-rinse treatment step, which are the bases of Applicants' invention, following the preamble. Further, the organic coatings, films, layers, and residues are more precisely defined in the post-preamble section to further distinguish over the greases and oils of Settineri et al. While it appears that at first glance, the two methods are similar, in point of fact, the method of Settineri, while purportedly useful for removing greases, oils, and graphitic carbon from sheet or bulk metal and glass surfaces, would fail to remove the organic coatings, films, layers, or residues from substrates of the devices enumerated in the claims.

It appears that the Examiner does not find Applicants' argument that "Settineri et al does not teach removal of the specifically claimed coatings, films, residues from the specifically claimed substrates" persuasive. The Examiner contends that "the residue of 'various organic compounds' recited by Settineri et al meet the limitation of the 'photosensitive and non-photosensitive organic materials' recited by the claims".

Applicants note that the residue of "various organic compounds" as described by Settineri et al refers to removal of films of greases, oils and graphitic carbon from sheet or bulk metal and glass surfaces. On the other hand, Applicant's invention is directed to the removal of claimed coatings, films and residues from the specifically claimed substrates in the processing of the claimed microelectronics-related devices. The distinction becomes lucid considering that today, a microelectronic device employs over five million transistors on the smallest surface area encompassed in the examples of Settineri et al, and this number is expected to near 100 million over the next 5 to 10 years, according to the prevailing Moore's law in the industry.

Manufacturing of such devices involves many complex steps in a very restrictive fabrication and clean-room environment. Both organic layers and substrates of the claimed invention are in the form of deposited films, with the film thickness being in the range of sub-micron to 10 micron. Furthermore, in the manufacturing steps prior to the application of the claimed invention, such coatings and such substrates are usually subjected to harsh plasma

chemistry or high-dose ion bombardment processes, whereby the thermal, physical, and chemical properties of the coatings and the substrates are severely altered.

Thus, the term "residue" in the case of microelectronic-related processes is a reference to altered organic materials, which are left behind after such plasma or other physical/chemical treatments. The presence of microscopic amounts of "residues" within the confines of very small, sub-micron features of the substrate can result in the catastrophic failure of the manufacturing process. In such cases, the macroscopic method of Settineri et al is not effective, and the coatings, films and residues are not effectively removed except by the method and process steps described in Applicants' invention, including the prescribed precursor and post-rinse treatments.

Applicants note that the macroscopic, bulk metal, glass and ceramic substrate surfaces recited by Settineri et al bear little resemblance to the extremely thin metal, oxide, glass, and organic film substrates used in microelectronics-related devices. Applicants' teach and claim a method of removing recited coatings, films and residues from the substrates in the recited devices, with a high selectivity ratio, while leaving substrate films completely intact without any damage. The effective removal of organic residues in such devices requires the method and process steps described in Applicants' invention, including the prescribed precursor and post-rinse treatments.

As specific examples, the method of Settineri et al will fail completely to remove organic photoresist layers which are first exposed to high-dose implant processes in the manufacturing of microelectronic devices. Similarly, the method of Settineri et al will fail completely to remove organic photoresist layers if such layers are exposed to fluorine etch chemistry during prior steps. In both cases, the resist surface becomes hardened and forms a barrier layer as a result of exposure to ion implant or fluorine plasma chemistry. None of the so-called pretreatment methods prescribed by Settineri et al will result in effective diffusion of sulfur trioxide through this barrier layer. The method of Settineri et al is equally ineffective in removing sidewall polymers and residues, which are formed in sub-micron holes and trenches, due to various etch chemistries employed in manufacturing semiconductor devices. In all these cases, pretreatment of the severely modified organic layers, prior to exposure to sulfur trioxide, by one or more of the physical or chemically reactive methods prescribed by

Applicants' invention, is necessary to ensure complete removal of the organic layer. In most cases, the post-treatment methods prescribed by Applicants' invention, will also be necessary to ensure complete removal of the organic layer and post-etch or post-implant residues.

As semiconductor device features approach the 0.1 micron range, new materials such as copper and organic dielectrics are employed in the manufacturing of semiconductor devices. In the particular, in the case of organic dielectric substrates, Applicants' invention is charged with selectively removing one organic coating from another organic substrate without damage or alteration in the physical or chemical properties of the latter. Similarly, the organic residues which are to be removed have the same constituent elements as the substrates to be left intact. The problems are compounded by the fact that, as described above, such organic coatings and residues are chemically altered and physically hardened by various etch and implant processes. In this connection, Setterini et al is totally silent regarding organic dielectric substrates.

In this regard, the Applicants' invention, in addition to the problem of removing hardened organic layers and residues, is concerned with both surface and bulk properties of the substrates after treatment with the claimed process steps of the invention. In particular, precursor treatments may be necessary to protect aspects of the surface property during the main step of exposure to water-free sulfur trioxide. Alternatively, post-rinse physical and chemical treatment may be necessary to restore surface or bulk properties of the substrate. Indeed, as new generations of semiconductor devices are contemplated by the device manufacturers, Applicants are continuously faced with the challenge of inventing new pretreatment and post-treatment methods to supplement the water-free sulfur trioxide process. Clearly, the macroscopic methods of Settineri et al are completely ineffective in dealing microscopic problems of selectively removing nanometer-size organic residues from new organic dielectric substrates, employed in new generations of semiconductor and other microelectronics-related device.

Therefore, the following points are summarized:

1. Applicants differ with the view of the Examiner and strongly contend that the residue of "various organic compounds" recited by Settineri et al do not meet the limitation of the "photosensitive and non-photosensitive organic materials" recited by the claims. In drafting

Claim 31, Applicants have revised the list of organic coatings, films, layers, and residues to specify that these may be either photosensitive or non-photosensitive organic materials and are selected from the recited group.

2. The bulk metal, glass and ceramic substrate surfaces recited by Settineri et al bear little resemblance to the extremely thin (sub-micron to a few microns thick) metal, oxide, glass, and organic film substrates used in microelectronics-related devices.

3. The use of a precursor treatment is required to modify the organic film prior to heating and flushing with nitrogen, when the physical or chemical properties of the coating are altered severely by a prior manufacturing step. Applicants' pretreatment discloses the use of several techniques to modify the organic film and make that film more susceptible to the mechanism of sulfur trioxide.

4. The use of post-rinse treatments becomes necessary in some embodiments for effectiveness of film removal or restoring the surface conditions of the thin substrates after the mechanism of sulfur trioxide.

5. The methods described by Settineri et al will fail completely to remove organic photoresist layers and residues which are exposed to high-dose implant or fluorine etch chemistry during prior processes.

6. The macroscopic methods of Settineri et al are completely ineffective in dealing with microscopic problems of selectively removing nanometer-size organic residues from new organic dielectric substrates, for the foregoing reasons.

Reconsideration of the rejection of Claims 3-23 and 25-30, as amended, together with new Claim 31, under 35 USC 102(b) as being anticipated by Settineri et al is respectfully requested.

Claims 1, 3-23, and 25-30 are rejected under the judicially-created doctrine of obviousness-type double patenting as being unpatentable over Claims 1-31 of U.S. Patent 5,763,016.

A Terminal Disclaimer, executed by the undersigned, is enclosed herewith. Applicants submit that the Terminal Disclaimer overcomes the rejection.

The foregoing amendments and arguments are submitted to place the application in condition for allowance. The Examiner is respectfully requested to take such action. If the Ex-

aminer has any questions, he is invited to contact the undersigned at the below-listed telephone number.

Respectfully submitted,

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